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FISH TAINTING

AN ASSESSMENT PROCEDURE

PREPARED FOR

WORKING GROUP II

OF THE WATER MANAGEMENT

STEERING COMMITTEE

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1981
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Ontario

Ministry
of the
Environment

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Deputy Minister

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An Assessment Procedure
Prepared for

Working Group II
of the Water Management
Steering Committee

D.L. Wells
Quality Protection Section
Water Resources Branch
August, 1981

NOTE

The receiving water assessment techniques presented in this report describe the methods commonly in use within the Ministry. Alternative techniques exist and/or will eventually be developed. Consultation with Ministry of the Environment staff is advisable to determine the suitability of the alternative techniques.

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TABLE OF CONTENTS

Page

Natural Sources 1
Man-Made Sources 1
Tainting Dynamics 2
Related Water Quality Parameters 2
Primary Investigation - Regional Office 3
Primary Investigation - District Office 3
Secondary Investigation - Head Office 4
Study Options 4
Basic Taste Test 6
Further Implications 6
Control Orders 7
Summary 7
Bibliography 9

FISH TAINTING

NATURAL SOURCES

Much of the current information available on fish tainting indicates that organic compounds rather than inorganic compounds are the source of fish flavour problems. These organic compounds may be from either natural or man-made sources.

Naturally occuring aquatic fungi can produce metabolites that will impair fish flavour. These fungi can be found in natural water bodies, in man-made organic sludge deposits (e.g. pulp fiber and/or bark fines) or in the effluent from an activated sludge sewage treatment plant. The compounds produced by these aquatic actinomycete result in a typical earthy, musty, or mouldy flavour in the fish. Fish having this type of taint appear to require at least three weeks in a clean water environment before the flavour is lost. Aromatic amines, ketones, aldehydes, saturated fatty acids and unsaturated aromatics have been associated with this problem.

MAN-MADE SOURCES

Direct, man-made sources of fish tainting are usually trade wastes that may vary in both concentration and composition. A complex effluent of this type which taints fish is analogous to a complex effluent which kills fish. It is usually not possible to identify a specific contaminant in a trade waste that is responsible for fish tainting or for fish mortality. Rather, the fish reacts to the total effluent.

Industrial effluents that have been identified as causing tainted fish include those from pulp mills, oil refineries, petrochemical plants and rubber manufacturing plants. Other likely sources would be effluents from coking plants, plants manufacturing rubber compounding chemicals and plants producing or processing chlorinated phenolic compounds.

TAINTING DYNAMICS

The routes of entry of the tainting compounds into the fish seems to be primarily through the gills[1] and possibly through contaminated food and the walls of the gut. The routes of elimination or depuration of these compounds from the contaminated fish are probably through the gills, kidney and gut. In most cases the flavour of fish can be impaired by an exposure of 48 hours. Longer exposures to non-tainting concentrations need not necessarily produce a tainted fish[2]. Similarly, longer exposure of fish to a tainting concentration need not necessarily increase the severity of the flavour impairment. There does not seem to be any information available relating flavour, duration of exposure and duration of depuration.

RELATED WATER QUALITY PARAMETERS

There is not a great deal of information available that describes the influence of water quality parameters on fish tainting. The rate of fish tainting may increase with increasing temperature. However, volatility and microbiological activity will also increase. An increase in temperature may accelerate the rate at which a fish acquires the taint but the maximum flavour impairment plateau may not be altered. Within the fish, the rate of metabolism and depuration will also be accelerated at higher temperatures.

Except when dissolved oxygen concentrations begin to harm fundamental metabolic processes there seems to be little correlation between fish tainting and oxygen concentrations.

The effects of pH on fish tainting are variable and unique to the pH characteristics of the compound being studied.

Effluents that are being examined for their capacity to impair fish flavour may contain "conservative" parameters that are useful in measuring degrees of waste dilution. Such parameters may be chloride, sulphate, sodium, dissolved solids or conductivity.

PRIMARY INVESTIGATION - REGIONAL OFFICE

Fish tainting problems can be identified through the activities of:

1. Ministry of the Environment
    - Regional Offices
    - Water Resources Assessment Staff
    - Industrial Abatement Staff
2. Ministry of Natural Resources
    - Conservation Officers
3. Public
    - sport fishermen
    - commercial fishermen
4. Other
    - Medical Officers of Health could be made aware of tainted fish although this has not happened to date.

PRIMARY INVESTIGATION AND EVALUATION - DISTRICT OFFICE

This step is most efficiently completed at the district level. Information needed at this time should include:

1) complete identification of the person or agency making the complaint,
2) identification of the area producing the tainted fish,
3) when and how often have the tainted fish been identified,
4) any descriptive terms relating to the off flavour of the fish.

The investigation at this stage is largely an information gathering process. One to several man days may be needed with a minimum of equipment or related expenses.

SECONDARY INVESTIGATION - HEAD OFFICE

As a result of the technology and techniques involved, the detailed investigation of tainting has become a centralized activity of the Toxicity Unit.

As the investigation becomes more focused an attempt will be made to determine the source of the tainting. If the source can be identified then a literature search (published sources plus MOE files) will be completed to gather the current information.

STUDY OPTIONS

At this point there are various options that can be taken.

1) A literature search and summary may be sufficient.
2) It may be necessary to collect wild fish from various sources in the study area including an uncontaminated control.
3) It may be necessary to run a controlled exposure of cultured fish at various sites in the study area.
4) It may be necessary to transport large volumes of water to Toronto for controlled laboratory exposure of fish. The three activities involving fish will be followed by a taste test to assess the flavour of the fish.

If it is relevant and available a gas chromatographic/mass spectrometric, GC/MS analysis of the water and fish samples will be completed.

If Option 2 is chosen then commercial fishermen and/or Ministry of Natural Resources conservation officers may be called upon to supply fish. In using wild fish to assess a tainting problem there are several important factors to keep in mind. Apart from collecting fish from widely separated areas, there is no means by which to estimate their exposure to the tainting environment either in terms of duration or concentration. Also, there must be good assurances that the control fish have no access to the study area. Wild fish collected for flavour evaluation probably represent the most natural condition to which a fisherman would find the fish exposed.

If Option 3 or 4 is selected then this approach will require almost total logistical support from the Toxicity Unit. By exposing cultured fish to a tainting environment, the duration of the exposure can be controlled but the fish are still subject to the basic variations in the natural environment. To a limited extent, careful selection of the various exposure sites can influence the concentration to which the fish are exposed. Option 2, and to a lesser extent, Option 3, are for monitoring the existing quality of the receiving water.

Option 4 is best implemented in conjunction with a specific discharge. Very useful implications can be drawn from Option 4 using the break point between a tainting and non-tainting concentration. Detailed chemical analyses can lead to an imperical decision as to the degree of waste treatment required to avoid tainting. For example, a waste that has a total organic carbon (T.O.C.) concentration of 200 mg/L could taint fish at 10% v/v but not at 1% v/v. Therefore, to avoid tainting problems associated with that waste, at least 90% of the T.O.C. (i.e. 180 mg/L) must be treated. Treatment steps that could be anticipated for a particular effluent could include any or all of the following:

1) in-plant flow segregation,
2) gravity oil-water separation,
3) flow equalization,
4) dissolved air flotation,
5) biological oxidation and clarification,
6) carbon filtration

A simple "before and after" fish exposure and taste test will help to evaluate the change in effluent quality brought about by the newly implemented treatment processes. A study, as outlined, must have adequate analytical support.

BASIC TASTE TEST

The elements of the taste test[3] involve a panel of six to eight people rating the flavour of cooked fish samples which have a known history of exposure and then comparing those flavours to those of a control sample(3). Within the group of experimental samples is one or more hidden controls. The panel must be able to distinguish these samples as being similar to the known controls. None of the tasted samples are swallowed and between each sample the panelists cleanse their mouths with unsalted soda crackers and diluted lemon juice.

The following five point scale is used by the panelists to score the flavour of samples.

1) Flavour same as or better than known control,
2) Slight, barely perceptible flavour impairment,
3) Moderate flavour impairment,
4) Strong flavour impairment,
5) Extreme repulsive flavour impairment.

The average score for each exposure condition is then compared statistically to the score of the unknown control. If there is a significant difference between the scores, then the experimental sample is considered to be tainted.

FURTHER IMPLICATIONS

The fact that a fish has acquired an off flavour means that it has taken up various organic contaminants from its environment. As far as the fish is concerned such an uptake need not necessarily be detrimental or beyond the limits of compensation. However, if the fish is consumed it may be:

1) unpalatable to the consumer,
2) constitute a direct health hazard to the consumer,
3) indirectly implicate other contaminants.

Tainting may represent more of a hazard to the consumer than to the fish population[4].

Organic contaminants in addition to making the fish unacceptable to the consumer may induce a variety of changes in the organism itself. Such changes may be alterations in tissue structure and/or function, alterations in behaviour or alteration in reproduction. In many cases rates of wash-out or depuration will have to be considered as well.

All these changes that may be induced in the organism must be interpreted in the light of inherent biological variability. These effects will also have to be carefully calibrated against recognized detrimental effects.

CONTROL ORDERS

The taste test was included in a control order against Polysar Corporation of Sarnia. This order contained a section requiring the company to complete fish tainting studies on its untreated and treated waste. The purpose of the tests was to demonstrate the effectiveness of the treatment system in removing tainting compounds from the final effluent.

SUMMARY

The tainting of fish flesh is generally associated with organic compounds of other man-made or natural origin. The gills act as primary site of entry of these substances into the fish. Through this route, tainting can occur within a matter of hours. The following steps should be observed in the examination of a tainting problem.

1) Identify the need for a tainting evaluation: Regional or Head Office.

2) Discuss the problem with support groups: Regional, Head Office and Analytical. Contact - G. Craig, Toxicity Unit, MOE.

3) Choose Method of Evaluation.

4) Implementation of test: Regional and Quality Protection Section.

5) Reporting and Interpretation: Regional and Quality Protection Section.

6) Incorporation of Results into Affirmative Action: Regional.

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